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angles, as shown in each system, and the general disagreement in the symbols hitherto assigned to the faces which make with some other face those nearly agreeing angles.

With regard to these facts he observes that no difference of opinion can arise, unless the sources from which they have been derived are incorrect; but that differences of opinion may be entertained relative to the interpretation of them.

The interpretation to which the author inclines is, that the near agreement in angle between two corresponding faces is not simply accidental, but that it is the effect of some natural relation not hitherto noticed, among all the crystals in each respective system; and hence, that where the angles between particular faces nearly agree, there ought to be a corresponding agreement in the forms of their symbols.

With this view of the subject in his mind, it occurred to the author that there might be a similar agreement among the whole of the elementary angles in each system, and an examination of the crystals in the pyramidal and rhombohedral systems to ascertain how far this conjecture might be well-founded, has shown that a geometrical isomorphism does exist throughout each of these systems, and that similar relations may therefore be imagined to exist in the other systems.

The author has also suggested that the oblique and anorthic systems are only hemihedral and tetartohedral varieties of prismatic crystals.

VI. "On some Compounds of Ethylene." By H. L. BUFF.  
Communicated by A. W. HOFMANN, Ph.D., F.R.S. Received June 10, 1856.

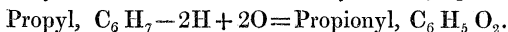
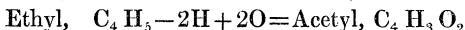
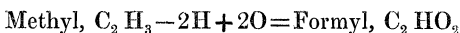
Among the hydrocarbons which are capable of replacing hydrogen, the radicals of the general formula  $C_n H_{(n+1)}$ , *i. e.* the homologues of ethyl, are best examined. There is another class of hydrocarbons which may be represented by the general formula  $C_n H_{(n-1)}$ . The only well-known term of this series is the radical allyl,  $C_3 H_5$ , to which the attention of chemists has been especially called of late by

the researches of Messrs. Hofmann and Cahours on allylic alcohol. These researches have established the most perfect parallelism between the two classes of radicals and their derivatives. Both the radicals  $C_n H_{(n+1)}$  and  $C_n H_{(n-1)}$  are *monatomic*, i. e. molecules capable of replacing 1 equiv. of hydrogen.

These two classes stand in the closest relation to each other, and it is by no means improbable that one class may pass over into the other, for instance, that the radical propyl  $C_3 H_7$ , or a propyl-compound, may be converted into allyl or an allyl-compound.

There exist a third series of hydrocarbons, which, again, both by composition and origin, are closely allied to the former two. They are represented by the general formula  $C_n H_n$ ; and methylene,  $C_2 H_2$ , ethylene,  $C_4 H_4$ , and propylene,  $C_6 H_6$ , are well-known terms belonging to this series. These hydrocarbons are also radicals; they differ, however, in their nature essentially from those of the former groups, inasmuch as they are *biatomic* molecules, i. e. molecules capable of replacing 2 equivs. of hydrogen.

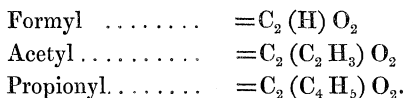
There exist parallel with these three series of radicals which form *alcohols*, three other groups of radicals, which *in acids* play exactly the same part that in the *alcohols* is assigned to the hydrocarbons. These acid-forming radicals contain, in addition to carbon and hydrogen, oxygen and other elements belonging to the oxygen group. They are closely connected with the radicals of the alcohols, and this close connexion is particularly well established between the first series of alcohol-forming radicals and the corresponding series of acid-forming radicals.



Formic, acetic and propionic acids are formed by the imperfect oxidation of methyl-, ethyl- and propyl-alcohol, and we may consider them to be simple substitution-products of these alcohols.

By means of the electric current we are able to produce ethyl, methyl and hydrogen from propionic, acetic and formic acids, and these acids we may reproduce again by the action of hydrate of potassa on the cyanogen compounds of hydrogen, methyl and ethyl.

Both series of radicals are chained together by these reactions, and we may view acetyl and propionyl as formyl, the hydrogen of which is replaced by methyl and ethyl.



There is no doubt that the same relation exists between the hydrocarbons of the other series of radicals and the radicals of the corresponding acids, between allyl,  $\text{C}_6 \text{H}_5$ , and the radical of acrylic acid, acryl  $\text{C}_6 \text{H}_5 \text{O}_2$ , and between methylene,  $\text{C}_2 \text{H}_2$ , ethylene,  $\text{C}_4 \text{H}_4$ , propylene, &c., and the radicals of the bibasic acids, which are homologues of succinic acid,  $\text{C}_8 \text{H}_6 \text{O}_8$ .

The biatomic radicals are in general far less studied than the monatomic radicals; still they occur in many compounds, and are met with in different departments of chemistry.

In addition to the terms already mentioned, we find them in the phenyl, benzyl, naphthyl and other series.

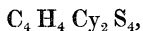
In the hope of adding some facts to the history of the polyatomic radicals, I have made some experiments with chloride of ethylene,  $\text{C}_4 \text{H}_4 \text{Cl}_2$ .

This compound, as well as the bromide of ethylene, refused to act in many instances; in others it underwent the same change which is induced by the action on it of a solution of potassa in alcohol, splitting into the compound  $\text{C}_4 \text{H}_3 \text{Cl}$  and hydrochloric acid.

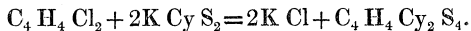
On boiling chloride or bromide of ethylene with an alcoholic solution of sulphocyanide of potassium, a very definite reaction takes place. The change being completed, the alcohol is separated by distillation, and the residue treated with a small quantity of cold water in order to remove chloride or bromide of potassium, which is produced, and the excess of sulphocyanide of potassium. The more or less coloured residue is then dissolved in boiling alcohol, and the solution, after digestion for some time with animal charcoal and a few drops of hydrochloric acid, filtered whilst hot. This solution deposits on cooling fine white, very brilliant and large rhombic plates of a hard and brittle substance\*.

\* Whilst M. Buff was engaged with these researches, M. Sonnenschein has communicated some experiments made in the same direction, which have likewise

The analysis of this substance leads to the formula



and its formation may be represented by the equation



Sulphocyanide of ethylene fuses at  $90^\circ \text{C}$ . and solidifies at  $83^\circ$ . It is but slightly soluble in cold water, more so in boiling water, from which it crystallizes in groups of needles. It is decomposed at a higher temperature, and evolves a highly pungent vapour, the odour of which very much resembles that of burnt onions. On boiling a solution of sulphocyanide of ethylene in water, a very acrid odour is observed, which produces lacrymation and violent sneezing. Sulphocyanide of ethylene has a sharp taste, causing a burning sensation in the throat.

Solution of ammonia decomposes sulphocyanide of ethylene even at the common temperature. A flocculent substance separates, and the solution contains several compounds which I have been unable to separate.

At the temperature of boiling water sulphocyanide of ethylene mixes with aniline in every proportion; no reaction, however, is perceptible. But on boiling the mixture decomposition sets in, and a volatile substance is evolved which restores the colour of reddened litmus paper.

When boiled with solution of hydrate of baryta and oxide of lead or mercury, sulphocyanide of ethylene loses its sulphur; the substance left behind possesses very little power of crystallizing. In the case of oxide of mercury, besides sulphide of mercury and carbonate of barium, a difficultly soluble body containing mercury is formed.

At the temperature of boiling water, sulphocyanide of ethylene dissolves readily in very dilute nitric acid; on cooling of the solution the substance is deposited unchanged. On treating it with stronger nitric acid a decomposition takes place, and a crystalline acid is formed. This acid is best produced by heating sulphocyanide of ethylene on the water-bath with dilute nitric acid as long as red

led to the discovery of this substance. Sonnenschein's results, which are published in the *Journ. für Prakt. Chem.* June 1855, came to our knowledge only after a summary of the results had been sent to the editor of the *Annalen der Chem. und Pharm.*—A. W. H.

fumes of nitrous acid are evolved. The residue is a strongly acid syrup, which becomes finally crystalline. It is repeatedly dissolved in water and evaporated on the water-bath in order to expel the nitric acid. Thus purified, the new acid is dissolved in boiling water, neutralized with pure carbonate of barium and separated from sulphate of barium. On cooling, the barium-salt of the new acid crystallizes. It is soluble in boiling water, less so in cold water, and almost insoluble in alcohol, by means of which it may be precipitated from its solution in water.

On examining the appearance and deportment of this salt, Dr. Hofmann, in whose laboratory I performed these experiments, at once recognized the identity of this compound with the barium-salt of disulphetholic acid which he and Mr. Buckton have lately discovered.

This view was fully confirmed by the analysis which I made.

The composition of the barium-salt, dried at  $160^{\circ}$ , is represented by the formula



The potassium salt of this acid is readily soluble in water; it crystallizes easily, and is likewise precipitated by alcohol from its solution in water. Dried at  $100^{\circ} \text{C.}$ , it contains



At  $160^{\circ}$  it suffers no decomposition; when exposed to a higher temperature, however, it blackens and intumesces, empyreumatic substances being evolved.

It is obvious that this bibasic acid stands in the same relation to ethylene as the monobasic ethylsulphurous acid to ethyl.

The origin of the two acids is perfectly analogous, the latter acid, according to Mr. Muspratt, being obtainable also by the action of nitric acid upon sulphocyanide of ethyl.

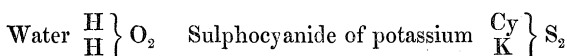
Sulphocyanide of ethyl,  $\text{C}_4 \text{H}_5 \text{Cy S}_2$ , produces ethylsulphurous acid,  $\text{C}_4 \text{H}_5$ ,  $\text{H}$ ,  $\text{S}_2 \text{O}_6$ .

Sulphocyanide of ethylene,  $\text{C}_4 \text{H}_4 \text{Cy}_2 \text{S}_4$ , produces ethylensulphurous acid,  $\text{C}_4 \text{H}_4$ ,  $2\text{H}$ ,  $2\text{S}_2 \text{O}_6$ .

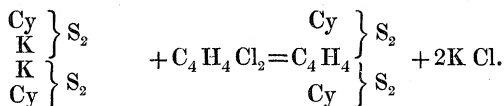
This reaction appears to throw some light upon the constitution of polybasic compounds. The compounds of monatomic molecules of the hydrogen-group with elements or compound radicals of the oxygen-group, are all remarkable for the simplicity of their construc-

tion. The union of biatomic radicals of the hydrogen-group with molecules of the oxygen-group gives rise to combinations of a far more complicated character. Whilst one molecule of water,  $\text{H}_2\text{O}_2$ , most conveniently may be considered as the type of many compounds of the former class, the corresponding compounds of biatomic radicals frequently correspond to a double molecule of water,  $2\text{H}_2\text{O}_2$ .

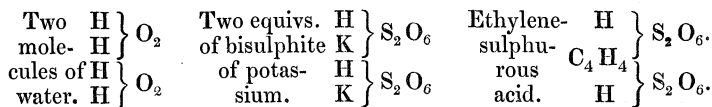
Sulphocyanide of potassium may be viewed as water, in which the oxygen is replaced by sulphur, one of the hydrogen molecules by cyanogen, the other by potassium.



In the production of sulphocyanide of ethylene two equivalents of chlorine in chloride of ethylene ( $\text{C}_4\text{H}_4\text{Cl}_2$ ) have to be eliminated by two equivalents of potassium. Thus the very reaction of the two factors, chloride of ethylene ( $\text{C}_4\text{H}_4\text{Cl}_2$ ), and two equivalents of sulphocyanide of potassium  $2(\text{K Cy S}_2)$ , joins 4 equivs. of sulphur and 2 equivs. of cyanogen with one molecule of ethylene. This reaction may be expressed by the following equation, which will illustrate at once my view in regard of the constitution of this substance :—

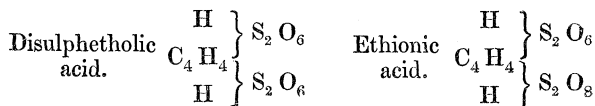


The acid produced by the action of nitric acid upon sulphocyanide of ethylene obviously belongs to the same type. In this compound, which in the conception of this view may be called *ethylene-sulphurous acid*, the cyanogen is replaced by hydrogen, whilst the sulphur has been oxidized into the compound radical  $\text{S}_2\text{O}_6$ , which in sulphurous acid we assume united with hydrogen.



Since we find that the hydrogen-molecules in polybasic acids are replaceable by two or more molecules of different metals or radicals,—witness tartrate of potassium and sodium, oxalovinate of potassium,—the idea naturally suggests itself that the biatomic alcohol-forming radicals may be capable of uniting two molecules of different elements

or compounds of the oxygen-group. It is probable, for instance, that the ethionic acid, discovered by M. Magnus, may be such a compound, namely *ethylene-sulphuro-sulphurous acid*.



The following Table contains some of the known ethylene and succinyl compounds compared with the corresponding derivatives of the ethyl and propionyl series.

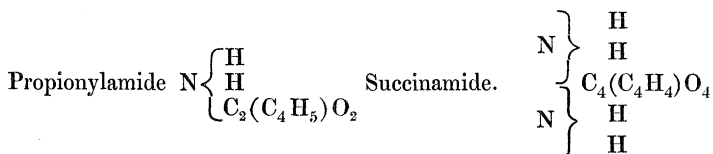
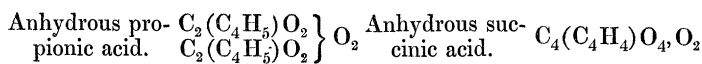
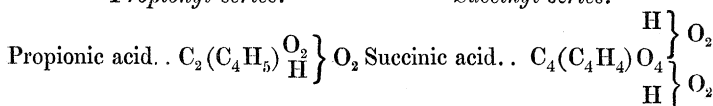
*Compounds of the Alcohol-forming Radicals.*

<i>Ethyl-series.</i>	<i>Ethylene-series.</i>
Ethyl . . . . . $\left. \begin{array}{c} \text{C}_4\text{H}_5 \\ \text{C}_4\text{H}_5 \end{array} \right\}$	Ethylene . . . . . $\text{C}_4\text{H}_4$
Chloride of ethyl $\text{C}_4\text{H}_5\text{Cl}$	Chloride of ethylene. . $\text{C}_4\text{H}_4\text{Cl}_2$
Sulphide of ethyl $\left. \begin{array}{c} \text{C}_4\text{H}_5 \\ \text{C}_4\text{H}_5 \end{array} \right\} \text{S}_2$	Sulphide of ethylene. . $\text{C}_4\text{H}_4\text{S}_2$
Mercaptan . . . . $\left. \begin{array}{c} \text{H}_5 \\ \text{H} \end{array} \right\} \text{S}_2$	Ethylene-mercaptan. . $\left. \begin{array}{c} \text{H} \\ \text{C}_4\text{H}_4 \\ \text{H} \end{array} \right\} \begin{array}{c} \text{S}_2 \\ \text{S}_2 \end{array}$
Sulphocyanide of ethyl. $\left. \begin{array}{c} \text{C}_4\text{H}_5 \\ \text{Cy} \end{array} \right\} \text{S}_2$	Sulphocyanide of ethylene. $\left. \begin{array}{c} \text{Cy} \\ \text{C}_4\text{H}_4 \\ \text{Cy} \end{array} \right\} \begin{array}{c} \text{S}_2 \\ \text{S}_2 \end{array}$
Bisulphide of ethyl. $\text{C}_4\text{H}_5\text{S}_2$	Bisulphide of ethylene $\text{C}_4\text{H}_4\text{S}_4$
Ethylsulphurous acid. $\left. \begin{array}{c} \text{C}_4\text{H}_5 \\ \text{H} \end{array} \right\} \text{S}_2\text{O}_6$	Ethylene-sulphurous acid. $\left. \begin{array}{c} \text{H} \\ \text{C}_4\text{H}_4 \\ \text{H} \end{array} \right\} \begin{array}{c} \text{S}_2\text{O}_6 \\ \text{S}_2\text{O}_6 \end{array}$
_____	Ethylene-sulphuro-sulphurous acid. $\left. \begin{array}{c} \text{H} \\ \text{C}_4\text{H}_4 \\ \text{H} \end{array} \right\} \begin{array}{c} \text{S}_2\text{O}_6 \\ \text{S}_2\text{O}_8 \end{array}$
Sulphovinic acid $\left. \begin{array}{c} \text{C}_4\text{H}_5 \\ \text{H} \end{array} \right\} \text{S}_2\text{O}_8$	

*Compounds of the Acid-forming Radicals.*

<i>Propionyl-series.</i>	<i>Succinyl-series.</i>
Chloride of propionyl. $\text{C}_2(\text{C}_4\text{H}_5)\text{O}_2\text{Cl}$	Chloride of succinyl. $\text{C}_4(\text{C}_4\text{H}_4)\text{O}_4\text{Cl}_2$



*Propionyl-series.**Succinyl-series.*

VII. "Description of an Instrument for registering Changes of Temperature." By BALFOUR STEWART, Esq. Communicated by J. P. GASSIOT, Esq., F.R.S., Chairman of the Kew Observatory Committee of the British Association. Received June 12, 1856.

It lately occurred to the author that advantage might be taken of the capillary action of mercury to construct an instrument similar to a thermometer, but in which the mercury should expand from heat only in one tube, and contract from cold only in another. Accordingly a bulb was blown between two thermometric tubes of differently-sized bores, in such a manner that the tubes lay in one straight line, with the bulb between them. The bulb was then filled with mercury, and the tubes were hermetically sealed at both ends, having been first carefully deprived of air. When the instrument thus constructed was laid in a horizontal position, or nearly so, its action was precisely what the author had hoped; the mercury contracting from cold only in the narrow bore, and expanding from heat only in the wide one,—even when viewed by a microscope of considerable magnifying power.

It was suggested by Mr. Welsh, Director of the Kew Observatory, that such an instrument might be used for measuring fluctuations of atmospheric temperature; and the following use afterwards occurred to the author. Were it required to exactly estimate the radiating